

P-7.1 Explain the particulate nature of light as evidenced in the photoelectric effect.

Revised Taxonomy Levels 2.7 B Explain conceptual knowledge
This concept was not addressed in physical science

It is essential for students to

- ❖ Understand the characteristics of the electromagnetic spectrum
- ❖ Understand the photoelectric effect as “The emission of electrons by a substance when illuminated by electromagnetic radiation is known as the photoelectric effect.”
 - Understand the laws of photo emission and how they describe the nature of electromagnetic radiation
 - The rate of emission of photoelectrons is directly proportional to the intensity of the incident light
 - The kinetic energy of photoelectrons is independent of the intensity of the incident light
- ❖ Understand the quantum theory and the equation $E = hf$ where f is the frequency in hertz, h is Plank’s constant, and E is energy expressed in joules

Assessment

The verb explain means that the major focus of assessment should be for students to “construct a cause and effect model”. In this case, assessments will ensure that students can model the nature of light based on classic experiments. Because the indicator is written as conceptual knowledge, assessments should require that students understand the “interrelationships among the basic elements within a larger structure that enable them to function together.” In this case, assessments must show that students can construct a cause and effect statement relating how the laws of photoemission define the particle nature of light

P-7.2 Use the inverse square law to determine the change in intensity of light with distance.

Revised Taxonomy Level 3.2 C_A Apply (use) procedural knowledge
Students did not address this indicator in physical science

It is essential for students to

- ❖ Understand that the quantitative study of light is called photometry and involves
 - Luminous intensity
 - Measured in candela (cd)
 - Measures the intensity of the source
 - Luminous flux
 - Symbol F , measured in lumens (lm)
 - Measures the rate at which luminous energy is being emitted, transmitted, or received
 - Illuminance
 - Symbol E , Measured in units of lm/m^2
 - Measures the density of the luminous flux on a surface
 - Understand how illuminance varies with the square of the distance from the source

Assessment

The other revised taxonomy verb for this indicator is implement (use), the major focus of assessment will be for students to show that they can “apply a procedure to an unfamiliar task”. The knowledge dimension of the indicator, procedural knowledge means “knowledge of subject-specific techniques and methods” In this case the procedure for implementing, photometry equations and using an inverse-square law. A key part of the assessment will be for students to show that they can apply the knowledge to a new situation, not just repeat problems which are familiar. This requires that students have a conceptual understanding of electric charge and electric fields.

P-7.3 Illustrate the polarization of light.

Revised Taxonomy Level 2.2 B Illustrate conceptual knowledge

Students did not address this indicator in physical science

It is essential for all students to

- ❖ Understand how the polarization of light illustrates that light is composed of transverse, not longitudinal waves
- ❖ Understand why light can be polarized
 - A single electron, vibrating horizontally, emits an electromagnetic wave that is vibrating horizontally
 - A single electron, vibrating vertically, emits an electromagnetic wave that is vibrating vertically
 - Light from a source, (candle, the sun, incandescent bulb) is not polarized because it is produced from many electrons, all vibrating in random directions.
 - When light strikes a polarized filter, the light that is transmitted is polarized.
- ❖ Understand how polarized glasses work
 - Light that reflects from a non-metallic surface generally vibrates in the same plane as the surface (light reflected from horizontal surfaces generally vibrates in the horizontal plane)
 - Polarized driving glasses have a polarized axis in the vertical direction, so that the reflected rays from the road and other horizontal surfaces are not transmitted through the glasses.
- ❖ Understand how polarized light facilitates 3-D viewing

Assessment

The verb exemplify (illustrate) means to find a specific example or illustration of a concept or principle; therefore, the major focus of assessment will be for students to give examples that show they understand how light is polarized, understand the implications of light polarization for our understanding of the nature of light, and how polarization is used in familiar devices.

Conceptual knowledge requires that students understand the interrelationships among the basic elements within a larger structure that enable them to function together. In this case, students understand how electromagnetic radiation produced from vibrating electrons results in transverse waves emanating in random directions.

P-7.4 Summarize the operation of fiber optics in terms of total internal reflection.

Revised Taxonomy Level 2.4 Summarize conceptual knowledge
Students did not address this topic in physical science

It is essential for all students to

- ❖ Understand the process of total internal reflection
 - Understand critical angle
 - Understand how the index of refraction of the substance influences the critical angle
- ❖ Understand how fiber optical fibers are constructed to facilitate the process of total internal reflection
- ❖ Understand how fiber optics are used in familiar objects and applications

Assessment

The revised taxonomy verb summarize means “to abstract a general theme or major point” For this indicator, the major focus of assessment should be to insure that students have a deep conceptual understanding of the process of total internal reflection and its role in fiber optics. Conceptual knowledge requires that students understand the interrelationships among the basic elements within a larger structure that enable them to function together. In this case, that students understand process of refraction and how the factors that influence refraction affect total internal reflection.

P-7.5 Summarize image formation in microscopes and telescopes (including reflecting and refracting).

Revised Taxonomy Level 2.4 Summarize conceptual knowledge

In physical science (PS-7.6) students

- ❖ Summarize refraction of light waves
 - Understand that lenses may be converging or diverging
 - Draw ray diagrams which illustrate the path of light through both converging and diverging lenses
 - Define real and virtual images

In physics, (P-5.5) students

- ❖ Use Snell's law and ray diagrams to illustrate the path of light and to find the location and size of the image.
 - as it passes through convex and concave of lenses
 - from a variety of distances in reference to the device and its focal length

It is essential for all students to

- ❖ Understand how optical devices depend upon the laws of reflection and refraction
 - The function of the lens and the eye piece and why both are necessary in telescopes
 - Lens, prism, and mirror function and arrangement in
 - Astronomical telescopes
 - Terrestrial telescopes
 - Binoculars
 - Compound microscopes

Assessment

The revised taxonomy verb summarize means “to abstract a general theme or major point” For this indicator, the major focus of assessment should be to insure that students have a deep conceptual understanding of the law of reflection and refraction and how they vital in the functioning of familiar optical devices. Conceptual knowledge requires that students understand the interrelationships among the basic elements within a larger structure that enable them to function together. In this case, that students understand laws of reflection and refraction and how the factors that influence reflection and refraction affect common devices and their functioning.

P-7.6 Summarize the production of continuous, emission, or absorption spectra

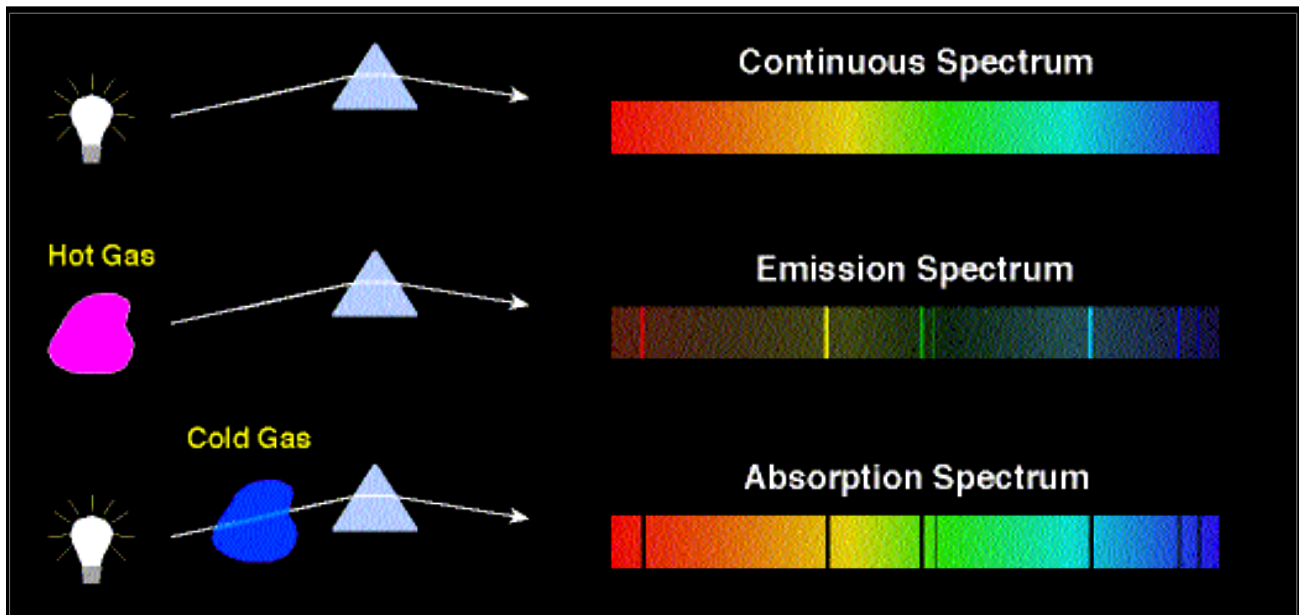
Revised Taxonomy Level 2.4 Summarize conceptual knowledge

Students did not address this topic in physical science

It is essential for students to

- ❖ Understand the origin of Continuous, Emission, and Absorption Spectra
 - When materials are made to glow, the electrons in their atoms jump to orbits of higher energy levels. As the electrons fall back to the ground state, the light from each different element produces its own characteristic pattern of lines because each element has its own distinct configuration of electrons, and these emit distinct frequencies of light when electrons change from one energy state to another.
 - A continuous spectrum
 - Generally, solids, liquids, or dense gases emit light at all wavelengths when heated to a glow.
 - This type of spectrum results from high pressure gasses or in solids and liquids because atoms are crowded together, causing many collisions among the particles.

➤ **An emission spectrum**



- Is produced by exciting a low density gases in which the atoms do not experience many collisions (because of the low density).
- The emission lines correspond to photons of discrete energies that are emitted when excited atomic states in the gas make transitions back to lower-lying levels.

➤ **An absorption spectrum**

- Is produced when light passes through a cold, dilute gas and atoms in the gas absorb the light at characteristic frequencies; since the re-emitted light is unlikely to be emitted in the same direction as the absorbed photon, this gives rise to dark lines (absence of light) in the spectrum.

Assessment

The revised taxonomy verb summarize means “to abstract a general theme or major point” For this indicator, the major focus of assessment should be to insure that students have a conceptual understanding of the three types of spectra that elements can emit Conceptual knowledge requires that students understand the interrelationships among the basic elements within a larger structure that enable them to function together. In this case, that students understand how the light emitted by the atoms appears to us.

P-7.7 Compare color by transmission to color by reflection.

Revised Taxonomy Level 2.6 Compare conceptual knowledge

Physical Science students do not address this indicator

It is essential for students to

- ❖ Understand that all colors of light in combination appear as white light
- ❖ Understand that black is the absence of light
- ❖ Understand that color can be distinguished by two means, reflection and transmission
 - Color by reflection
 - The electrons surrounding each specific type of atom vibrate with a frequency that is characteristic of that atom.
 - In one material electrons vibrate easily at certain frequencies, in another material electrons vibrate easily at different frequencies
 - Light that is incident on a material will be absorbed if the frequency of the light matches the resonant frequency of the vibrating electrons
 - Most materials absorb light of some frequencies and reflect the rest
 - An object can reflect only light of frequencies present in the illuminating light
 - The color that an object appears is dependent upon the combination of the frequencies of light that are reflected by the object
 - Color by transmission
 - The color of a transparent object depends on the combination of colors of light it transmits.
 - The material in the glass that selectively absorbs colored light is known as a pigment

Assessment

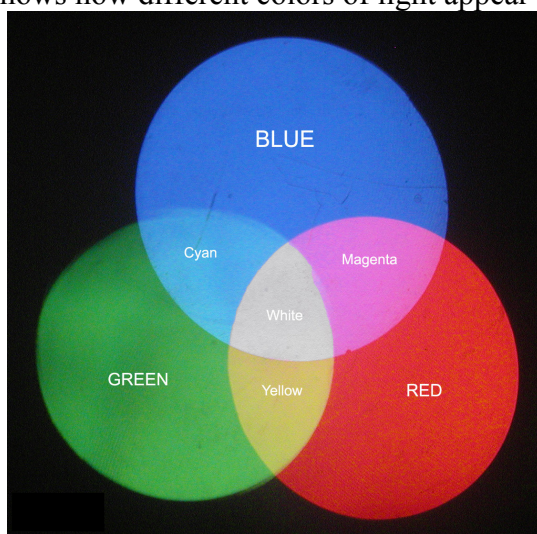
As stated in the indicator, the major focus of assessment is to compare (detect correspondences) in the ways colors are produced by color absorption and by color transmission. Because the indicator is written as conceptual knowledge, assessments should require that students understand the “interrelationships among the basic elements within a larger structure that enable them to function together.” In this case, assessments must show that students understand the reasons for the difference in the ways that transparent materials and opaque materials show color.

P-7.8 Compare color mixing in pigments to color mixing in light

Revised Taxonomy Level 2.6 Compare conceptual knowledge

Students did not address these principles in physical science.

- Mixing colored lights
 - Also called mixing colors by addition
 - If the frequencies of light are divided into three regions, the low frequency red, the middle frequency green and the high frequency blue
 - The middle and high frequencies combined appear cyan to the human eye
 - The middle and low frequencies combined appear yellow to the human eye
 - The low and high frequencies combined appear magenta to the human eye
 - The middle, low and high frequencies combined appear white to the human eye
 - The chart below shows how different colors of light appear



- Mixing colored pigments
 - Also called mixing colors by subtraction
 - Pigments absorb particular wavelengths and reflect particular wavelengths
 - The primary wavelengths reflected are listed in the chart below

Pigment	Absorbs	Reflects
Red	Blue, Green	Red
Green	Blue, Red	Green
Blue	Red, Green	Blue
Yellow	Blue	Red, Green
Cyan	Red	Blue, Green
Magenta	Green	Blue, Red

- However pigments also reflect some wavelengths that are close in frequency to the color reflected. (Blue pigment reflects not only blue light but also some frequencies of green and violet)
- When the pigments are mixed, the frequencies of light that are not absorbed by either pigment are reflected

Assessment

As stated in the indicator, the major focus of assessment is to compare (detect correspondences) in the ways different colors are produced by mixing lights and by mixing pigments. Because the indicator is written as conceptual knowledge, assessments should require that students understand the “interrelationships among the basic elements within a larger structure that enable them to function together.” In this case, assessments must show that students understand the reasons for the difference in the colors that result when light is mixed and when pigments are mixed.

P-7.9 Illustrate the diffraction and interference of light.

Revised Taxonomy Level 2.2 B Illustrate conceptual knowledge

In physical science students conceptually understood diffraction of light and examples of diffraction patterns as well as constructive and destructive interference.

In physics standard P-5 students analyze the diffraction of waves.

It is essential for all students to

- ❖ Understand the circumstances under which light will diffract
 - Through a slit opening
 - Around a fine wire
 - Around a sharp-edged object
- ❖ Understand the functioning of diffraction gratings
- ❖ Understand how to use the equation
$$\lambda = d \sin\theta_n/n$$
to find the wavelength of light where
 - θ = the diffraction angle
 - d = the grating constant
 - n = the order of the image
- ❖ Understand single-slit diffraction and the patterns which are produced by this process

Assessment

The verb exemplify (illustrate) means to find a specific example or illustration of a concept or principle; therefore, the major focus of assessment will be for students to give examples that show they understand how light is diffracted causing interference. Conceptual knowledge requires that students understand the interrelationships among the basic elements within a larger structure that enable them to function together. In this case, students understand how diffraction patterns can be produced in light